Regional Operational Plan CF.4K.2019.02

Operational Plan: Estimation of Fishing Power Correction Factors for the R/V *Resolution* Relative to the R/V *Solstice*, Using Large-Mesh Bottom Trawl Survey Gear in the Kodiak District, 2019

by

Kally Spalinger

April 2019

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN CF.4K.2019.02

OPERATIONAL PLAN: ESTIMATION OF FISHING POWER CORRECTION FACTORS FOR THE R/V *RESOLUTION* RELATIVE TO THE R/V *SOLSTICE* USING LARGE-MESH BOTTOM TRAWL SURVEY GEAR IN THE KODIAK DISTRICT, 2019

by

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Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak

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Division of Commercial Fisheries

April 2019

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SIGNATURE PAGE

Project Title:	Operational plan: Estimation of fishing power correction factors for the R/V *Resolution* relative to the R/V *Solstice* using large-mesh bottom trawl survey gear in the Kodiak District, 2019
Project Leader(s):	Kally Spalinger
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Project Nomenclature:	
Period Covered:	June 2019
Field Dates:	
Plan Type:	Category II

Approval

Title	Name	Signature	Date
Project Leader	Kally Spalinger		
Biometrician	Ben Williams		
Section Supervisor	Mark Stichert		

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PURPOSE

The purpose of this project is to provide fishing power correction factors for the Alaska Department of Fish and Game (ADF&G) R/V *Resolution* relative to the ADF&G R/V *Solstice.* Large-mesh bottom trawl survey gear that is standard to trawl surveys in the Kodiak District will be used. Fishing power correction factors estimated from this study will be used to quantify differences in catchability between the R/V *Resolution* which has recently undergone structural changes, and the R/V *Resolution* prior to the upgrade with the goal of preserving the continuity of the large-mesh trawl survey data time series.

The R/V *Resolution* has been operated by ADF&G to conduct marine resource surveys for more than 45 years, and since 1988 has conducted standardized, fishery-independent large-mesh bottom trawl surveys in the Westward Region. Trawl surveys are the basis of stock assessment for crab and groundfish management. Data from trawl surveys conducted by R/V *Resolution* are relied upon by ADF&G fishery managers in state-managed Tanner crab *Chionoecetes bairdi* fisheries in the Kodiak, Chignik, South Peninsula, and Eastern Aleutian districts. Additionally, data from these trawl surveys contribute to federal stock assessments for groundfish species, including walleye pollock *Gadus chalcogrammus*, Pacific cod *Gadus macrocephalus*, sablefish *Anoplopoma fimbria*, and northern and southern rock sole *Lepidopsetta polyxystra* and *L. bilineata*.

In 2018 R/V *Resolution* underwent upgrades that included repowering and widening. Fishery managers must account for changes in catchability that may occur when altering a vessel to maintain a data time series. Systematic error may be introduced into the data time series if indices are not adjusted to account for changes in fishing power resulting from changes in vessel catchability. To compare survey results between years when utilizing different sampling platforms data must be collected to correct for differences in catch.

The R/V *Resolution* was repowered and widened in the winter of 2017/2018. In anticipation of this, ADF&G performed a fishing power comparison study in 2015 and 2017 alongside R/V *Solstice* to collect data intended to estimate fishing power correction factors relative to R/V *Resolution* before structural changes and engine replacement began. This was the first step in determining if catchability differences exist between R/V *Resolution* from 1988–2017 and R/V *Resolution* beginning in 2018, and to estimate correction factors for survey data collected (Spalinger 2015a).

In 2019 ADF&G will conduct a fishing power comparison study using R/V *Solstice* and the newly modified R/V *Resolution* to provide the second data set for the analysis which will ultimately provide correction factors to ensure large-mesh trawl survey data collected through 2017 can be accurately compared to data collected since 2018.

Keywords: large-mesh, bottom trawl, fishing power, Kodiak, Tanner crab, groundfish, survey, R/V *Resolution*, R/V *Solstice*

OBJECTIVES

The objectives of the 2019 fishing power comparison study are as follows:

1. Conduct 30 to 50 paired tows using R/V *Resolution* and R/V *Solstice* in the Northeast and Eastside sections of the Kodiak Tanner crab management district.
2. Document species composition, fish lengths, and crab sizes according to established large-mesh trawl survey methods (Spalinger 2015b).

3. Quantify species-specific differences in fishing power between the two vessels. Species of particular interest are Tanner crab, walleye pollock, Pacific cod, arrowtooth flounder *Atheresthes stomias*, and flathead sole *Hippoglossoides elassodon*.

METHODS

A fishing power comparison study will take place June 3–10, 2019 during the large-mesh bottom trawl survey for crab and groundfish. The ADF&G R/V *Resolution* and R/V *Solstice* will each perform trawl tows in standard large-mesh survey stations in the Northeast and Eastside sections of the Kodiak Tanner crab District.

SURVEY AREA AND DESIGN

The Northeast and Eastside sections of the Kodiak Tanner crab District (Figure 1) include Pacific Ocean waters south of the latitude of Cape Douglas (lat 58°51.10′ N), west of long 149° W, east of a line extending north from Shuyak Island along long 152°20.00′ W, east of long 152°30.00′ W in Shuyak Strait, east of a line between Inner Point and Afognak Point along long 152°47.75′ W, northeast of a line extending 168° from Cape Barnabas at lat 57°09.07′ N, long 152°52.20′ W, and east of long 153°16.00′ W in Sitkalidak Strait.

The large-mesh bottom trawl survey samples a fixed grid of stations every year in areas of known Tanner crab habitat. Survey stations generally represent crab and fish habitat greater than 20 fathoms deep, although some inshore stations have had more specific habitat identified using a combination of bathymetry and bottom type. In the Northeast and Eastside sections offshore stations average approximately 68.6 km^2 each and inshore stations average approximately 18.8 km^2 each.

Since trawl nets perform differently at different depths survey stations in the Northeast and Eastside sections were categorized by depth strata (Table 1) to ensure that samples are collected from stations representing all depths encountered in the survey. Stations were selected for sampling considering four criteria: they are large enough that more than one tow can be made without overlap; they include stations of varying distances from shore; they represent each depth stratum; and they include stations sampled in 2015 and 2017 (Table 2; Figure 2). Additional stations in the Northeast and Eastside sections may be sampled as time allows (Table 1). Vessel captains, in consultation with cruise leaders, will determine station sampling order based on weather and time constraints.

VESSEL AND FISHING GEAR

The R/V *Resolution* is a house-forward stern trawler equipped with an aft net reel, telescoping deck crane, and paired hydraulic trawl winches. Prior to 2018 it was 27.7 m long and 7.9 m wide; it is now 28.9 m long and 10.9 m wide. The R/V *Solstice* (17.4 m) is a house forward limit seiner equipped with an aft net reel, a hydraulic boom, and paired trawl winches.

The survey net used by each vessel is a 400-mesh eastern otter trawl designed to sweep a 12.2 m path. The net is constructed with 10.2 cm stretch mesh at the mouth; 8.9 cm stretch mesh in the body, and a 3.2 cm stretch mesh liner in the codend. The net has a 21.3 m headrope with 18 floats 20.3 cm in diameter. The footrope is 29.0 m long with a 1.0 cm diameter chain attached every 25.4 cm to ensure the footrope tends bottom. The dandylines are 45.7 m long, each consisting of an 18.3 m section of 1.5 cm cable and a pair of 27.4 m sections of 1.3 cm cable, one attached to the top and the other to the bottom of each net wing. Diagrams of the net and cable configuration are

found in Spalinger (2015b). Astoria "V" type doors weighing 340 kg and measuring 1.5 m x 2.1 m are used.

Within each station, the trawl net is towed on the bottom at an average speed of 4.0 to 4.5 km/h for a target distance of 1.85 km, equivalent to 1 nmi. The length of the haul provides a representative sample of fishery resources from each survey station without exceeding the weight limitations of the vessel equipment. Irregular bottom type, net hang ups, or exceptionally large catches often cause haul lengths to differ from 1.85 km. Haul length is determined by a Global Positioning System and is assumed to be the distance traveled over the ground by the vessel from the time the footrope contacts bottom until the time the footrope leaves bottom. The vessel captain estimates corrections in distance for hauls that are not straight. Haul location is limited to locations of trawlable substrate as determined from nautical charts and bottom mapping software on the vessel. All hauls are made during daylight hours. Haul location, distance, time, and depth are recorded on ADF&G skipper trawl record forms (Spalinger 2015b). Quality of net performance is rated and a haul is discarded and repeated when the skipper and cruise leader determine the net did not adequately contact the bottom.

In each station designated for paired hauls, vessels will tow as close together as safely possible without towing the exact same track. The timing of hauls should be within two hours of each other to reduce variability from tidal and current changes. Vessel captains should maintain communications with one another to ensure haul lengths and vessel speed are similar between boats.

Temperature and Depth Data Logger

On each vessel, depth and bottom temperature will be recorded using a XR-420-TD data logger (RBR Ltd., Ottawa, Canada) during each haul. The data logger is attached to the headrope of the net and is approximately 2 m above the sea floor when fishing. Water temperature and depth are recorded in one-minute intervals for each haul. Temperatures recorded while the net is on the bottom are used to calculate the average haul temperature.

CATCH SAMPLING

Biological sampling on each vessel will follow methods described in the large-mesh trawl survey operational plan (Spalinger 2015b) with some modifications for sampling onboard R/V *Solstice*. R/V *Solstice* does not have a crane so the main boom will be used to lift and weigh the codend. To transfer the subsampling net from the on-deck sorting bin to the subsample sorting area, the picking boom will be used.

During the paired hauls, R/V *Resolution* will conduct standard sampling tasks and continue Tanner crab chela height collection and other special projects (Knutson *in prep*). R/V *Solstice* will focus only on standard catch sampling tasks and will not be responsible for collecting chela heights or participating in other special projects.

Data Entry

Data entry methods on R/V *Resolution* and R/V *Solstice* will follow procedures outlined in Spalinger (2015b). Electronic data will be backed up daily. Catch and length data written on the on-deck sampling forms (Spalinger 2015b) will be entered on each vessel. Data from skipper forms will be manually entered into the survey database at the end of each day. Upon completion of the

fieldwork all data will be verified and edited as needed, then provided to the Fisheries Scientist for data analysis.

Data Forms and Sample Custody

The cruise leader will complete all data forms and remove samples and data from the vessel, including making backup copies of electronic data. Data forms and electronic data removed from the vessel will be delivered to the large-mesh trawl survey project leader.

SAMPLE SIZE

The target number of paired tows to perform is 50, with a minimum of 30 needed for analysis. With a limited number of days available for the study 30 tows may not be possible, so as many paired tows will be conducted as possible from June 3 to 10; multiple paired tows may be conducted in a single station if bottom type and station size allow. A similar number of stations from each depth strata will be sampled.

DATA ANALYSIS

Fishing power correction factors must be calculated for each species independently because factors such as reactions to a trawl, bottom tending habits, and other ecological characteristics of fish are likely species-specific (Von Szalay and Brown 2001). Initial data analysis will focus on commercially-important species whose survey data are needed by fishery managers. Those species, in order of priority, are:

1. Tanner crab,
2. walleye pollock,
3. Pacific cod,
4. arrowtooth flounder, and
5. flathead sole.

Correction factors for other species will be determined as time allows based on input from fishery managers and researchers. Eventually correction factors will be determined for all species.

The estimator, $\widehat{FPC}$, used to estimate fishing power correction factors for R/V *Solstice* relative to R/V *Resolution* is based on a randomized block analysis of variance (DuPaul and Rudders 2008). By treating each tow pair as a block, this approach partitions out inter-tow variability and the vessel effect can be estimated. Catch per unit effort (CPUE) data for a given species will be log transformed to account for any single zero catch in a tow pair. The estimated $ln(CPUE + 1)$ for tow pair j is the grand mean (μ), plus the estimated vessel effect (v_i) and the estimated haul effect (h_j). The haul effect is treated as the randomized block in the model.

$$\ln\left(CPUE_{ij} + 1\right) = \mu + v_i + h_j + \varepsilon_{ij}\,, \qquad (3)$$

where the parameters μ, v_i, and h_j are referenced as above and ε_{ij} represent the random error term.

By design, $v_{Resolution} = -v_{Solstice} = v$.

The fishing power correction factor is estimated as

$$\widehat{FPC} = \frac{\widehat{CPUE}_{Resolution}}{\widehat{CPUE}_{Solstice}} = e^{2v(1+0.5s^2)}. \qquad (4)$$

To estimate the FPC, the estimated average CPUEs of the 2 vessels are calculated as,

$$\widehat{CPUE}_{Resolution} = e^{\mu+v} \text{ and } \widehat{CPUE}_{Solstice} = e^{\mu-v}, \qquad (5)$$

where s^2 = the variance of the parameter estimate of v. Confidence intervals for the estimates of $\widehat{FPC}$ will be calculated via bootstrapping and the percentile (95%) method (Efron and Tibshirani 1993).

SCHEDULE OF ACTIVITIES AND DELIVERABLES

The schedule of activities and deliverables for the 2019 trawl comparison study is as follows:

Date	Activity
June 2	R/V *Solstice* arrives in Kodiak, load survey gear and staff
June 3–10	Perform paired tows in Northeast and Eastside sections using R/V *Resolution* and R/V *Solstice*
June10	Vessels return to Kodiak, staff begins editing data
June 11	Unload survey gear and staff, R/V *Solstice* returns to Kachemak Bay
August 1	Editing of data complete, delivered to biometrician for data analysis
October 1	FPC factors for Tanner crab, walleye pollock, and Pacific cod determined

RESPONSIBILITIES

List of personnel and duties:

R/V *Resolution*

Fishery Biologist II, Natura Richardson: Cruise leader. Assist with sampling, data collection, and data entry.

Fish and Wildlife Technician III, Sherry Barker: Assist with sampling, data collection, and data entry.

Fish and Wildlife Technician III, Collin Hakkinen: Assist with sampling, data collection, and data entry.

Fish and Wildlife Technician II, Joy Brooks: Assist with sampling, data collection, and data entry.

Boat Officer IV, Denis Cox Jr.: Operate survey vessel.

Boat Officer III, Kurt Pedersen: Vessel engineer. Deploy/retrieve survey gear, assist with catch sampling.

Boat Officer II, Gary Wilson: Deploy/retrieve survey gear, assist with catch sampling.

R/V *Solstice*

Fishery Biologist II, Kally Spalinger: Project leader, prepare sampling gear, develop survey schedule, cruise leader, perform data verification/editing, assist biometrician with data analysis, and report writing.

Fishery Biologist III, Nathaniel Nichols: Assist with sampling, data collection, and data entry.

Fishery Biologist I, Michael Knutson: Assist with sampling, data collection, and data entry.

Boat Officer III, David Anderson: Operate survey vessel.

Vessel Technician, James Wiese: Deploy/retrieve survey gear, assist with catch sampling.

Boat Officer I, Clayton Hamilton: Deploy/retrieve survey gear, assist with catch sampling.

Fisheries Scientist I, Ben Williams: Assist in development of study methods, perform data analysis.

Analyst/Programmer IV, Ric Shepard: Program and manage the trawl survey database, load new data and create data verification queries.

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TABLES AND FIGURES

Table 1.–Stations and haul depth within each depth strata in the Eastside and Northeast sections of the Kodiak Tanner crab District.

Stratum 1			Stratum 2			Stratum 3			Stratum 4		
Station	Depth (10–100 m)	District	Station	Depth (100–125 m)	District	Station	Depth (125–150 m)	District	Station	Depth (150–209 m)	District
486B	71	Eastside	654	101	Eastside	588	146	Eastside	559	155	Eastside
510C	90	Eastside	486A	102	Eastside	589	135	Eastside	560	152	Eastside
511B	79	Eastside	510D	102	Eastside	619	137	Eastside	561	152	Eastside
KLA	95	Eastside	511A	104	Eastside	695	143	Eastside	587	152	Eastside
KLB	84	Eastside	534B	101	Eastside	533A	145	Eastside	620	154	Eastside
KLC	93	Eastside	KLE	115	Eastside	533B	146	Eastside	621	154	Eastside
KLD	27	Eastside	KLF	123	Eastside	534D	130	Eastside	655	152	Eastside
UGAA	75	Eastside	KLG	119	Eastside	535A	135	Eastside	656	165	Eastside
UGAB	64	Eastside	KLI	123	Eastside	535B	126	Eastside	696	176	Eastside
UGAC	33	Eastside	UGD	101	Eastside	535D	141	Eastside	535C	154	Eastside
UGB	90	Eastside	UGM	104	Eastside	KLH	134	Eastside	257	159	Northeast
UGC	93	Eastside	285	101	Northeast	KLL	130	Eastside	283B	172	Northeast
UGE	97	Eastside	420	124	Northeast	255B	128	Northeast	313	198	Northeast
UGF	88	Eastside	421	119	Northeast	256	135	Northeast	395	209	Northeast
UGG	68	Eastside	369X	115	Northeast	284	132	Northeast	444	163	Northeast
UGI	99	Eastside	CHB	104	Northeast	443	146	Northeast	255A	154	Northeast
UGJ	69	Eastside	CHJ	110	Northeast	CHF	141	Northeast	283A	155	Northeast
314	59	Northeast	KZE	121	Northeast	CHG	143	Northeast	CHL	201	Northeast
CHA	35	Northeast	KZR	121	Northeast	CHK	146	Northeast	KZK	183	Northeast
CHE	16	Northeast	KZS	102	Northeast	KZF	126	Northeast	KZO	198	Northeast
KZA	46	Northeast	MOEX	115	Northeast	KZG	130	Northeast	MOGX	176	Northeast
KZB	53	Northeast				KZJ	130	Northeast	MOLA	198	Northeast
KZC	60	Northeast							MONX	192	Northeast
KZD	88	Northeast							MOPA	170	Northeast
									MOLB	152	Northeast
									MOPB	166	Northeast
									MOXA	170	Northeast
									MOXB	170	Northeast

Note: Stations are not listed in order of sampling priority.

Table 2.–Stations selected for sampling in the 2019 fishing power correction study.

Stratum 1	District	Stratum 2	District	Stratum 3	District	Stratum 4	District
486B	Eastside	486A	Eastside	535A	Eastside	535C	Eastside
510C	Eastside	510D	Eastside	535B	Eastside	257	Northeast
KLC	Eastside	511A	Eastside	535D	Eastside	283B	Northeast
UGAA	Eastside	KLE	Eastside	255B	Northeast	255A	Northeast
UGAB	Eastside	KLF	Eastside	256	Northeast	283A	Northeast
UGB	Eastside	KLG	Eastside	284	Northeast	313	Northeast
UGC	Eastside	KLI	Eastside	CHF	Northeast	CHL	Northeast
UGE	Eastside	UGD	Eastside	CHG	Northeast	KZK	Northeast
UGF	Eastside	UGM	Eastside	CHK	Northeast	KZO	Northeast
UGG	Eastside	285	Northeast	KZG	Northeast	MOGX	Northeast
UGI	Eastside	CHB	Northeast	KZJ	Northeast	MONX	Northeast
UGJ	Eastside	CHJ	Northeast			MOLA	Northeast
CHA	Northeast	KZR	Northeast			MOLB	Northeast
314	Northeast	KZS	Northeast			MOPA	Northeast
						MOPB	Northeast
						MOXA	Northeast
						MOXB	Northeast

Note: Stations selected for sampling were large enough that more than one tow could be made without overlap, include stations of varying distances from shore, and represent each depth strata. Additional stations from Table 1 may be towed by both vessels if time allows or circumstances require modification. Stations are not listed order of sampling priority.

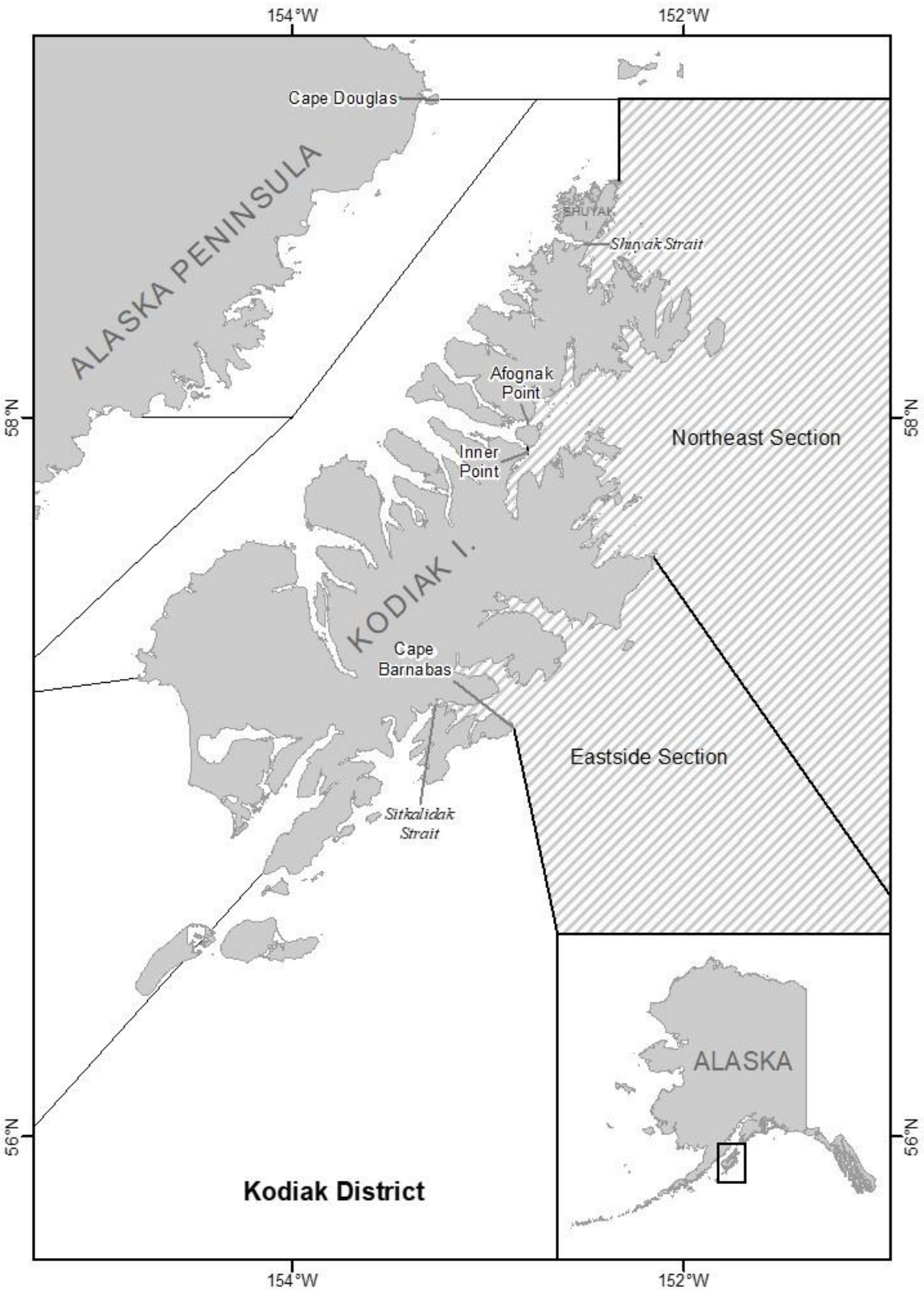

Figure 1.–Map of the Kodiak Tanner crab management district highlighting the Northeast and Eastside sections.

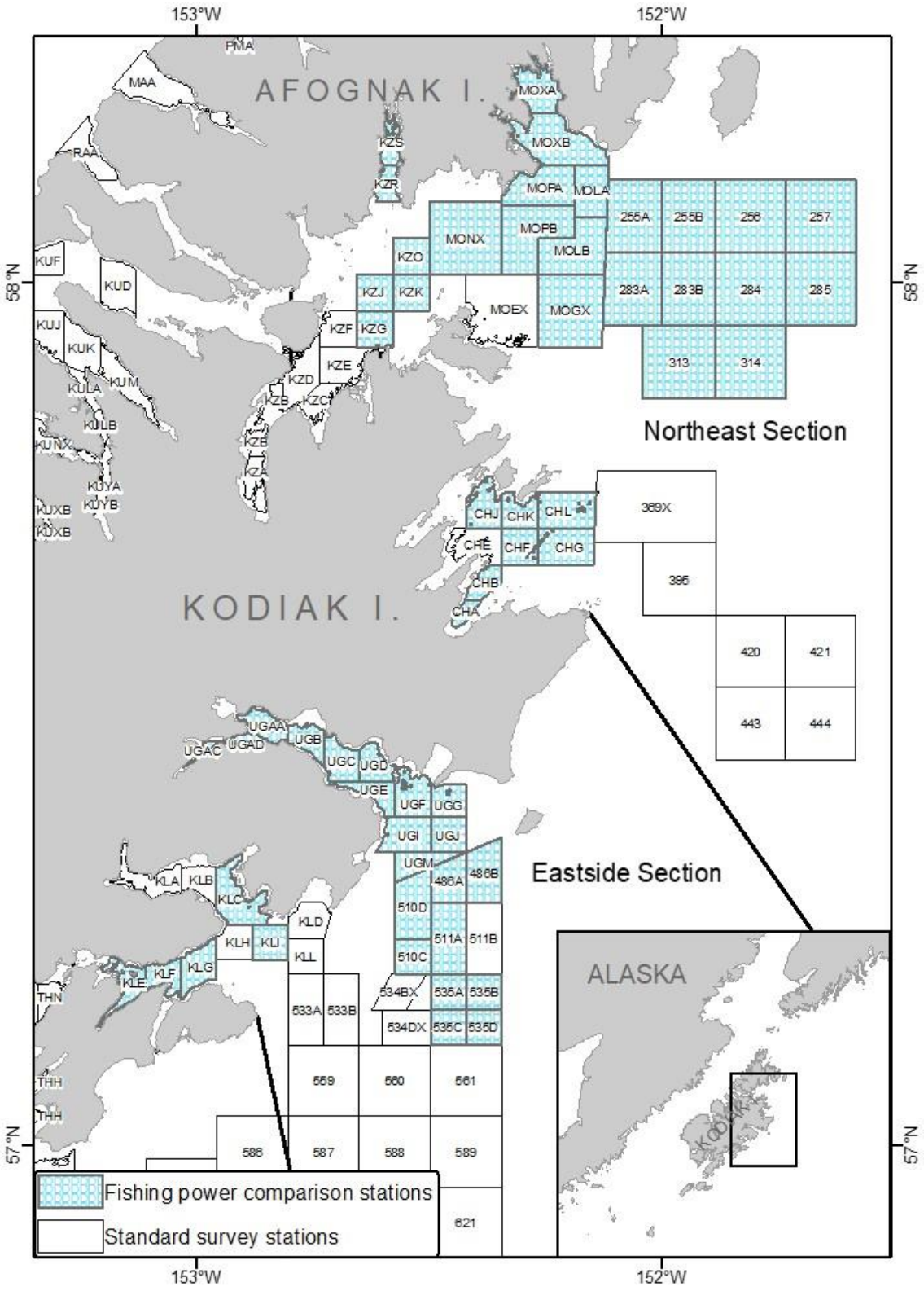

Figure 2.–Stations to be sampled during the 2019 fishing power correction survey between the R/V *Resolution* and the R/V *Solstice* in the Northeast and Eastside sections of the Kodiak District.